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54 **HYBRID ENGINE GROUP**

57 The inventions concerns a hybrid engine group for a motor vehicle, of a type comprising an internal combustion engine and an electric motor, of a type in which, in certain operation modes of the internal combustion engine, the latter is supplied with a so-called lean air/fuel mixture in which the air is in excess relative to the fuel, and of a type in which the internal combustion engine includes an exhaust circuit provided with a device for storing the nitrogen oxide molecules present in the exhaust gases;

characterized in that in certain engine operating modes, the type of usage of the electric motor is determined by the engine control unit in order to maintain the temperature of the exhaust gases in the storage unit of the nitrogen oxide molecules within a specified temperature range.

HYBRID ENGINE GROUP

The invention concerns a hybrid engine group in which an electric motor is used to control the temperature of the exhaust gases in the area of the exhaust-gas treatment device.

More particularly, the invention concerns an engine group for a motor vehicle of a type comprising an internal combustion engine able to propel at least one driving wheel of the vehicle and an electric motor that can be used as a generator or according to a motor mode in which it contributes to the propulsion of the vehicle, of a type in which, in certain operating modes of the internal combustion engine, the latter is supplied with a so-called lean air/fuel mixture in which the air is in excess in relation to the fuel, and of a type in which the internal combustion engine includes an exhaust circuit provided with an exhaust-gas treatment device.

More particularly, the invention is described within the framework of a special hybrid engine group. The engine group is composed of an internal combustion engine provided with an electric motor inserted (integrated) in the inertia flywheel. In such a group, the electric motor can only deliver a very small part of the maximum output of the vehicle's thermal engine. The motor is connected to the inertia flywheel of the thermal engine, i.e., actually, the inertia flywheel is essentially formed by the rotor of the electric motor. Therefore, the latter is directly connected to the drive shaft of the thermal engine, and is generally inserted between the thermal engine and a transmission element such as a

gearbox.

Within this framework, the electric motor generally is a device that can be used either in motor mode or in generator mode. In generator mode, the electric motor replaces the alternator to supply the electric current to be used in the vehicle's electric circuit or to be stored in the accumulators of a battery. In the motor mode, on the other hand, the electric motor is supplied with a current previously stored in the battery and provides engine torque to the drive shaft; this engine torque, therefore, is added to the torque of the thermal engine in order to be transmitted to the driving wheels of the vehicle.

Until now, it has been known to use the electric motor in a motor mode to start up the thermal engine, to reduce the cycles (RPMs) of the thermal engine when it operates at idle speed, or to supply, for a short period, a boost to the torque allowing, for instance, to facilitate an uphill start or while passing another vehicle.

However, the invention is not limited to such an engine group and, consequently, in can be applied in all hybrid engines in which the thermal engine may have to propel the vehicle alone.

The invention is designed for application to engine groups in which the internal combustion engine can operate with a lean mixture. Engine operation in lean mode allows limiting fuel consumption when the driver does not require a high torque. However, within the framework of a combustion engine in which the exhaust gases must be purified, the operation with a lean fuel mixture causes

development of nitrogen oxide molecules (NOx), the reduction of which is impossible with a conventional catalyst because, then, the exhaust gases form an oxidizing environment.

Therefore, in order to prevent these nitrogen oxides from escaping into the atmosphere, it is known how to store them in a storage device, also called NOx a trap.

Such a NOx trap allows storing the NOx molecules produced when the engine operates with a lean fuel mixture, provided that the temperature of the device is contained within a specific temperature range, for instance between 250 and 450ºC. When, on the contrary, the engine is supplied with a rich, carbureted fuel mixture, i.e., having an excess of fuel in relation to air, the exhaust gases become reducers, which allows reduction of nitrogen oxides NOx in order to be able to again operate the engine in a lean mode.

Furthermore, it appears that NOx traps not only can store nitrogen oxides (NOx) but they can also store sulfur oxides (SOx). Yet, if the storage of sulfur oxides can occur at the same temperatures as the storage of nitrogen oxides, reduction of the sulfur oxides can only take place when the exhaust gases form a reducing environment and when the temperature of the storage device is greater than a given temperature, for example greater than 650ºC.

Consequently, in order for the NOx trap to operate efficiently, it is necessary to occasionally clean it to free the sulfur oxides.

Therefore, to ensure complete purification of the exhaust gases, it is

necessary to be able to control the temperature of the nitrogen oxide (NOx) storage device. But, the temperature of this device essentially depends on the temperature and flow rate of the exhaust gases passing through it.

Thus, in order to control the temperature of the NOx storage device, the temperature of the exhaust gases must be controlled.

However, the exhaust-gas temperature essentially depends on the engine load, i.e., on the volume of the fuel injected in the cylinder(s) during each cycle. However, it is not sufficient to act on the engine load to change the temperature because the load also determines the delivered torque, and it is this latter parameter that is most important because it must be continuously adjusted so as to correspond as closely as possible to the torque requirement formulated by the driver by, for example, pressing the accelerator pedal.

Likewise, in the previous method, it is proposed to be able to modify the temperature of the exhaust gases without modifying the torque supplied by the engine by acting on the ignition (spark) advance.

However, by modifying the ignition (spark) advance, the engine's thermal output (performance) is also greatly modified and, in order to increase the temperature of the exhaust gases, one must modify the ignition (spark) advance, thereby reducing the performance (output). Thus, in order for the engine to provide the torque requested by the driver, it will be necessary to use a greater amount of fuel to the detriment of the vehicle's fuel consumption.

Because of that (therefore), the goal of the invention is to propose a new

design for the engine group described above, in which the thermal engine and the electric motor are controlled so that they react at all times to the driver's prompting (requests) with low fuel consumption and allowing, at all times, perfect (complete) purification of the exhaust gases.

To that end, the invention proposes an engine group of the above-described type, characterized in that in certain operating modes of the engine group, the operating mode of the electric motor is determined by a control unit of the engine group in order to maintain the exhaust-gas temperature in the treatment device within a specific temperature range.

According to the characteristics of the invention:

- the treatment device is a storage unit for the nitrogen oxide molecules present in the exhaust gases;
- in some operating modes of the engine group, the thermal engine is supplied with a lean mixture, and the torque request becoming greater than the threshold value at which the temperature of the NOx storage device is greater than the maximum storage temperature, the control unit of the engine group orders the electric motor, in its motor operating mode, to supply engine torque corresponding to the torque requirement, so as to maintain the exhaust-gas temperature within a temperature range allowing NOx storage, while supplying the combustion engine with a lean fuel mixture;
- the combustion engine is provided with a direct fuel injection system in

the cylinder(s), thanks to which, in certain engine operating modes, it is supplied with a stratified air/fuel mixture in which the fuel distribution in the cylinder is not homogeneous, and that in certain operating modes of the engine group, the thermal engine being supplied with a stratified lean fuel mixture, and the torque requirement becoming greater than a threshold value at which the temperature of the NOx storage unit becoming greater that a threshold value at which the temperature of the NOx storage unit becomes greater than a maximum storage temperature, the control unit of the engine group controls the electric motor, in its motor mode, to supply engine torque so as to meet the torque requirement, in order to maintain the temperature of the exhaust gases within a temperature range allowing the storage of nitrogen oxides while supplying the combustion engine with a stratified fuel mixture;

- in certain engine operating modes, in order to maintain the temperature of the NOx storage unit above a minimum temperature, the control unit commands the electric motor, in its generator mode, to provide a resistant torque opposing the engine torque delivered by the combustion engine, the latter being controlled to supply a torque equal to the sum of the torque requested by the driver and the resistant torque of the electric motor, in order to produce an increase in the temperature of the exhaust gases;
- in its generator mode, the electric motor is commanded to maintain the

temperature of the NOx storage unit within a temperature range allowing purging of the sulfur oxides contained in the NOx storage unit;

- in its generator mode, the electric motor is commanded to maintain the temperature of the NOx storage unit within a temperature range allowing the storage and reduction of the NOx storage;
- the combustion engine is a direct-injection engine;
- the electric motor is integrated with the inertia flywheel of the combustion engine;
- the combustion engine is an engine with controlled ignition.

Other characteristics and advantages of the invention will become evident by reading the following detailed description and, for an understanding of which, please refer to the attached drawings in which:

> Figure 1 is a schematic view depicting an engine group according to the invention;
> Figures 2A and 2D are graphs illustrating the operation of a state-of-the-art engine;
> Figures 3A and 3D are graphs depicting, under the same conditions, the operation of an engine group according to the invention, optimized to limit fuel consumption and pollution;
> Figure 4 is a chart showing the main steps of a first control unit of an engine group integrating (including) the teachings of the invention;
> Figures 5A and 5D are graphs illustrating the management of a

state-of-the art engine group when having to increase the temperature of the exhaust gases to allow purging of sulfur oxides SOx;

- Figures 6A and 6D are graphs depicting the control of an engine according to the invention to allow reduction of the sulfur oxides retained in the storage unit; and
- Figure 7 is a chart showing the main steps of a second control process of an engine group according to the invention allowing assurance of purging function.

Figure 1 schematically shows a hybrid engine group, 10, more particularly an engine group 10 composed of a thermal engine, 12, for instance an internal combustion engine with alternating pistons, provided with an electric motor, 14, integrated with the inertia flywheel. Therefore, the rotor, 16, of electric motor 14 is solidary (forms a single piece) in rotation with the drive shaft, 18, of thermal engine 12, so that electric motor 14 is inserted between thermal engine 12, so that electric motor 14 is inserted between thermal engine 12 and a transmission element, 20, which can, for instance, be a gearbox with a clutch.

A central control unit, 22, controls the operation of thermal engine 12 and electric motor 14 as a function of the various parameters and, notably, as a function of torque Cd requested by the driver.

The driver of the vehicle expresses a torque demand by acting on an

interface such as an accelerator pedal.

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Thermal engine 12 supplies engine torque Cmot while electric motor 14 imposes (torque) Cme on the drive shaft which is positive when the electric motor is used as a generator. Thus, engine group 10 supplies the transmission device with torque Cgmp that is equal to the algebraic sum of torques Cmot and Cme.

When it is used as a generator, electric motor 14, whose rotor 16 is then pulled in rotation either by drive shaft 18 or by transmission 20, produces a current that can be used by an electric circuit of the vehicle or stored in a battery.

According to the teachings of the invention, thermal engine 12 is an engine that can operate with a lean fuel mixture, that is, a carbureted fuel mixture in which the air is in excess relative to the amount of fuel. Of course, the engine is used in a lean operating mode only for relatively low loads, i.e., relatively low torque requirements on the driver's part, the maximum engine output being achievable only with a fuel richness equal to or greater than the unit richness, i.e., when the carbureted fuel mixture has an excess of fuel in relation to the stoichiometric balance of the combustion reaction.

In the preferred operating mode of the invention, internal combustion engine 12 is an engine with controlled ignition and direct fuel injection.

Direct fuel injection allows using especially lean carbureted fuel mixtures, the igniting of the mixture being favored by the fact that the direct injection allows

feeding the engine with a lean stratified load, i.e., a load in which the fuel injected in the cylinder is not homogeneously distributed in it at the time of the ignition, the fuel then gathering as close to the sparkplug as possible so that the local concentration is sufficient to start the combustion. With regard to a homogeneous lean fuel mixture, a stratified lean mixture can allow appropriate engine operation with even less fuel, thereby benefiting the fuel consumption of the engine group.

According to the invention, engine 12 is also equipped with an exhaust-gas purification device. Traditionally, it being a controlled ignition engine, it includes a 3-way catalyst allowing considerable reduction of the hydrocarbon (HC) nitrogen oxide (NOx) and carbon monoxide (CO) content of the exhaust gases.

However, such a 3-way catalyst generally works only for richness values very close to the unitary value, i.e., only when the carbureted fuel mixture exhibits a stoichiometric fuel/air ratio between the volumes introduced in the fuel mixture for combustion. The stoichiometric ratio is 1 g fuel per 14.7 g air.

Thus to ensure effective purification of the exhaust gases when the engine is operating with a lean mixture, a NOx storage device, the so-called NOx trap, is also provided. In effect, when the engine is supplied with a lean fuel mixture, the emission of hydrocarbons (HC) and carbon monoxides (CO) is very low, whereas, on the contrary, excess oxygen tends to favor the formation of nitrogen oxide molecules (NOx).

Consequently, when the engine is in a lean operating mode, the nitrogen oxides are stored in the storage unit. On the other hand, when the engine is

supplied with a stoichiometric fuel mixture of with a rich fuel mixture, it is possible to reduce the volume of nitrogen oxide molecules trapped in the storage unit.

According to a first aspect of the invention, central control unit 22 of engine group 10 controls thermal engine 12 and electric motor 14 so that, when the engine is operating with a lean fuel mixture, the exhaust-gas temperature is such that the storage unit is kept within a temperature range between a low temperature Tmin, for example 250ºC, and a high temperature Tmax, for example 450ºC. The NOx storage- and storage-reduction reactions can take place within this temperature range.

Figures 2A and 2D show a conventional method for controlling the temperature of exhaust gases in a case of an engine operating in a lean mode.

Figures 2A shows vehicle speed V as a function of time. This is a case when the driver wants to accelerate the vehicle in order for the vehicle to go from speed V1, for example 70 km/h, to speed V2, for example 100 km/h, within t1 and t3 instants. To produce this acceleration, thermal engine 12 must be controlled so that it supplies an additional torque to allow for this acceleration.

Figure 2B shows the temperature of the exhaust gases that would result from control of the thermal engine if the latter were kept operating with a lean mixture. It can be seen that up to instant t1, the engine is controlled to maintain the vehicle at speed V1 (70 km/h), and the temperature of the exhaust gases in the NOx trap is, for example, equal to temperature T1 (400ºC). This is within the storage range where the storage operation can take place efficiently.

Then, from instant t1, the additional torque requested from thermal engine 12, operated in lean mode, would produce an increase in the temperature of the exhaust gases, which during acceleration, could attain a temperature equal to temperature t2, for example 500ºC, i.e., greater than NOx storage temperature Tmax. In effect, the curve shows that beyond instant 12, the temperature of the exhaust gases would exceed 450ºC.

Therefore, there is a torque threshold, Cs, beyond which the thermal engine cannot go when it is supplied with a lean fuel mixture without the temperature of the exhaust gases exceeding the temperature at which the NOx trap attains a temperature greater than the maximum storage temperature, which is 450ºC. This torque Cs is lower than the maximum torque that the engine can deliver in a lean operation.

Therefore, in order to prevent the nitrogen oxides from being emitted to the atmosphere, one can see in figure 2C, showing the richness, R, of the carbureted fuel mixture supplied to the engine, that from instant t2, the thermal engine according to the state of the art, must be controlled so that it is supplied with a carbureted stoichiometric fuel mixture in order to allow the 3-way catalyst to purify the exhaust gases. But such switch of operation of the thermal engine is detrimental to fuel consumption, partly due to the fact that the performance of the engine is not as good under unitary richness than when a lean fuel mixture is used, which is further reinforced by the fact that switching the operating modes produces a transitory phase during which the engine performance is particularly poor.

Figure 2D shows the temperature variation curve of the NOx trap when the engine is controlled according to the technological state of the art, as shown in figure 2C. It can be seen that from instant t2, during the switch in stoichiometric mode, the temperature of the exhaust gases in the trap increases considerably, always in order to attain the same acceleration allowing the vehicle to go from 70 to 100 km/h. This time, the maximum temperature can reach 600ºC, which is further reinforced by the fact that, at unitary richness, combustion of the CO and HC takes place in the NOx trap, an especially exothermic reaction, contributing to the temperature increase. As figure 2D shows, this temperature increase extends well beyond the end of the acceleration period and tends to keep the temperature in the trap at a temperature greater than the maximum storage temperature of 450ºC, although, as can be seen in greater detail in figure 2B, it would be theoretically possible to maintain the vehicle at its new speed V2 by supplying the engine with a lean fuel mixture and by obtaining temperature T3 (approx. 430ºC) of the exhaust gases in the trap, which is a temperature compatible with the storage reaction.

Therefore, as figure 2C shows, the engine must be kept in a stoichiometric operating mode well beyond instant 14 starting at which, one can envision, beyond the purification problems, driving again in a lean mode to keep the vehicle at a speed of 100 km/h.

Figures 3A to 3D show a control mode of an engine group according to the invention that allows, during an acceleration of the type described above,

maintaining thermal engine 12 in a lean operating mode, this, of course without causing emission of nitrogen oxides to the atmosphere. The graphs in figures 3A and 3B are identical to those in figures 2A and 2B.

The graph in figure 3C, depicting the operation of electric motor 14, shows that starting at instant t2, beyond which the torque requested by the driver becomes greater than the threshold torque Cs that the thermal engine is able to supply without the temperature of the storage unit exceeding the maximum NOx storage temperature Tmax, electric motor 14 is controlled to operate in the engine mode where it provides engine torque to the driving wheels of the vehicle, of course, by using the electric energy previously stored in the battery.

Figure 3C shows an operating mode of engine group 10 in which, beyond the acceleration period, the electric motor is used as a generator, for example, to recharge the battery. However, under other engine operating functions, electric motor 14 could be at rest or be used as a motor as a function of the other operating parameters of the vehicle.

The invention rests on the fact that one of the parameters based upon which control unit 22 is controlled is, directly or indirectly, the temperature of the NOx trap.

Furthermore, figure 3D shows that the temperature of the storage unit remains within the temperature range in which the NOx storage reactions are possible. At the same time, as figure 3A shows, engine group 10 delivers sufficient torque for the vehicle to accelerate according to the driver's wish.

At instant t3, when the acceleration stops and the torque demand drops, the

torque level demanded by the driver is lower than the previously defined threshold torque. It is then possible to gradually reduce the intervention of electric motor 14 so that only the thermal engine, having been continuously supplied with a lean fuel mixture, is used to propel the vehicle.

Thus, thanks to the invention, the switch from a lean operating mode of the thermal engine to a stoichiometric operation is prevented, thereby benefiting the performance and fuel consumption of the engine group.

To activate the control process of the engine group according to the invention, one can follow the main steps of the chart in figure 4. In this chart, in step 100, it is first verified whether or not the demanded torque Cd is lower than the threshold torque Cs defined above. If yes, it is sufficient to operate thermal engine 12 so that it delivers the torque Cd requested by the driver without having to modify the operating mode and the engine is able to operate with a lean fuel mixture.

Otherwise, the engine torque to be delivered by electric motor 14 is calculated in step 110. This torque Cme is equal to the difference of torque Cd requested by the driver minus threshold torque Cs.

In step 120, notably as a function of the charge status of the battery, it is checked whether or not the electric motor is able to deliver this torque.

If this is possible, engine group 10 is controlled by control unit 22 in such a way that thermal engine 12 delivers a torque equal to its threshold torque Cs while electric motor 14 delivers the engine torque Cme calculated in step 110. Thus,

engine group 10 provides the vehicle with the total torque Cgmp = Cs + Cme, which is equal to the torque Cd requested by the driver.

In a case where, for example, the battery charge status does not allow electric motor 14 to provide sufficient torque, in order to satisfy the request for torque Cd without generating emission of nitrogen oxides, the engine operating mode must be switched, thermal engine 12 then being supplied with a stoichiometric fuel mixture and being controlled so as to deliver an engine torque Cmot equal to the torque demanded by the driver.

In the above example, a control method of engine group 10 was described that allows, in some cases, preventing switching the thermal engine from a lean operating mode to an operation with a homogeneous fuel mixture.

However, within the framework of a direct-injection thermal engine, the same type of control strategy can be used to prevent the engine from switching from operating with a stratified lean fuel mixture to an operating mode with a homogeneous lean fuel mixture in order to further improve the performance of the engine group.

Another application of the invention is envisioned for purging the sulfur oxides contained in a nitrogen oxide storage unit (trap).

In fact, such a reduction of sulfur oxides SOx can occur only when the temperature in the storage unit is greater than threshold temperature Ts, for example equal to 650ºC. Of course, such a sulfur oxide reduction, which is the result of a reduction reaction, can only take place when the exhaust gases form a

reducing environment, i.e., only when thermal engine 12 is supplied with a carbureted fuel mixture whose richness is at least equal to 1, i.e., greater.

However, even when then engine is supplied with a stoichiometric mixture, it is rare that, under normal vehicle operating conditions, the exhaust gases allow the storage unit to attain such a temperature.

Likewise, when the vehicle is traveling at a stabilized speed, for instance at speed V1 (100 km/h), in order to obtain a temperature increase without modifying the torque delivered by thermal engine 12, according to the technological state of the art, the ignition (spark) advance of engine 12 must be modified in order to lower its output (yield). Thus, during the entire duration of the purge comprised between instants t1 and t2, value A of the spark advance is reduced, as shown in figure 5B, and at the same time, to compensate for the reduced output, opening angle αpap of the air intake throttle (butterfly) valve is increased as shown in figure 5C, which, with a unitary richness, corresponds to an increase in the fuel volume introduced in the cylinders during each cycle.

Thus, figure 5D shows that, thanks to this artifice, an exhaust-gas temperature reaching temperature Ts necessary for reduction of the sulfur oxides, i.e., a temperature of 650ºC, can be attained. However, when this procedure according to the state of the art is used, it can be seen that, during the entire sulfur oxide-purging period, the thermal engine must be supplied with more fuel, without this fuel increase being required by the driver in order to accelerate or by the presence of a hill to be climbed.

On the contrary, thanks to the procedure according to the invention, as figures 6A and 6D show, the increase in the exhaust-gas temperature obtained, as figure 6C shows, is due to the fact that during this entire period, the thermal engine is supplied with a fuel volume that allows obtaining such a temperature increase.

However, thanks to the invention, it is not necessary to reduce the engine output to maintain a constant speed. In fact, according to the invention, the central control unit controls electric motor 14 in such a way that, during the entire purge duration, motor 14 produces an electric current, i.e., it operates in a generator mode. Electric motor 14 then absorbs the torque and control unit 22 controls motor 14 in such a way that the absorbed torque is equal to the excess torque supplied by the thermal engine in relation to the torque demanded by the driver.

Thus, contrary to the technological state of the art, the temperature increase obtained by burning a greater amount of fuel is not lost because the additional energy delivered by this fuel is transformed into electric energy that is stored in the battery and can be used later on.

As in the first implementation example of the invention, the electric motor could, outside the purge periods, be used in a motor mode or be at rest, as a function of the other vehicle operating parameters.

Figure 7 shows a chart depicting the main steps of a process that allows performing, according to the invention, a purge of the sulfur oxides contained in the nitrogen oxide storage unit.

Initially, in step 200, control unit 22 of engine group 10 controls the thermal

engine so that it is supplied with a carbureted fuel mixture in stoichiometric proportions, that is, at the unitary richness. Then, in step 210, it is checked whether or not temperature T of the NOx storage unit is greater than the minimum purging temperature Ts, i.e., approx. 650ºC.

If yes, which can be the case at a high load when the driver demands a high torque, the central control unit leaves electric motor 14 at rest and controls the thermal engine to deliver all the torque Cd requested by the driver.

For the contrary case, that is if temperature T of the NOx storage unit is below temperature Ts of 650ºC, in step 220 the value of torque Cme to be absorbed by the electric motor 14 is evaluated to determine whether an increase corresponding to the torque supplied by the thermal engine is the source of a sufficient increase in the exhaust gas temperature to attain the necessary temperature for the NOx storage unit. Therefore, torque Cme is a negative torque and it is verified, still in step 220, as a function of the charge state of the battery, if it is actually possible for electric motor 14 to absorb such a torque.

If yes, the thermal engine is commanded to deliver torque Cmot that is equal to torque Cd demanded by the driver minus torque Cme supplied by electric motor 14, which is negative because then electric motor 14 absorbs the output.

In step 230, it is checked whether temperature T of the NOx trap is greater than the threshold level Ts of 650ºC. If yes, control unit 22 continues to control engine group 10 until the purging operation of the sulfur oxide molecules has ended.

If this temperature of 650ºC is never reached, a spark advance modification strategy is implemented which, by replacing the above-described strategy or by complementing it, allows, as seen in the description of the technological state of the art, an increase in the temperature of the exhaust gases.

The second implementation example of the invention describes an engine control unit in which it is attempted to maintain the temperature of the nitrogen oxide storage unit above the sulfur oxide-purging threshold level Ts. Of course, the same procedure can be adapted to maintain said temperature above the minimum NOx storage and reduction temperature Tmin.

The scope of the invention can be extended to all engine groups in which the operating mode of the electric motor is determined as a function of the operating temperature of a device for the treatment of exhaust gases, regardless of type.

PATENT CLAIMS

1. An engine group for a motor vehicle of the type comprising an internal combustion engine (12) able to drive at least one driving wheel of the vehicle, and an electric motor (14) that can be used in generator mode or in motor mode in which it participates in the propulsion of the vehicle, of the type which, in certain operating modes of the internal combustion engine (12), is it supplied with a lean air/fuel mixture in which the air is in excess relative to the fuel, and of the type in which the internal combustion engine (12) comprises an exhaust system provided with an exhaust-gas treatment

device, characterized in that in certain operating modes of the engine group (10), the operating mode of the electric motor (14) is determined by a control unit (22) of the engine group in order to maintain the exhaust-gas temperature inside the treatment device within a determined temperature range.

2. The engine group as per claim 1, characterized in that the treatment device is a trap for the nitrogen oxide molecules present in the exhaust gases.

3. The engine group as per claim 2, characterized in that, in certain operating modes of the engine group, the thermal engine (12) being supplied with a lean fuel mixture and torque (Cd) requirement becoming greater than a threshold value (Cs) at which the temperature of the nitrogen-oxide storage unit becomes greater than a maximum storage temperature (Tmax), the control unit of the engine group commands the electric motor (14), in its motor mode, to supply an engine torque (Cme) in order to fulfill the torque (Cd) demand, in order to maintain the exhaust-gas temperature within a temperature range allowing for storage of the nitrogen oxides while supplying the internal combustion engine (12) with a lean fuel mixture.

4. The engine mixture group as per claim 3, characterized in the combustion engine is provided with direct fuel injection in the cylinder thanks to which, in certain engine operating modes, it is supplied with a stratified air/fuel mixture in which the fuel distribution in the cylinder in not homogeneous, and in that, in certain operating modes of the engine group, the thermal

engine (12) being supplied with a stratified lean fuel mixture and the torque (Cd) demand being greater than a threshold value (Cs), at which the temperature of the nitrogen oxide storage unit is greater than a maximum storage temperature (Tmax), the control unit (22) of the engine group (10) commands the electric motor (14) in its motor mode to deliver engine torque (Cme) in order to satisfy the torque (Cd) request, in order to maintain the temperature of the exhaust gases within a temperature range allowing for storage of the nitrogen oxides while supplying the combustion engine (12) with a stratified fuel mixture.

5. The engine group as per claim 2, characterized in that, in certain engine operating modes, in order to maintain the temperature of the nitrogen-oxide storage unit above a minimum temperature (Ts), the control unit (22) commands the electric motor (14), in its generator mode, to deliver a resistant torque (Cme) opposing the engine torque supplied by the combustion engine (12), the latter being controlled to deliver a torque (Cmot) equal to the sum of the torque (Cd) requested by the driver and the resistant torque (Cme) of the electric motor (14) in order to produce an increase in the temperature of the temperature of the exhaust gases.

6. The engine group as per claim 5, characterized in that the electric motor (14), in its generator mode, is controlled to maintain the temperature of the nitrogen-oxide storage unit within a temperature range that allows purging the sulfur oxides contained in the nitrogen-oxide trap.

7. The engine group as per claim 5, characterized in that the electric motor, in its generator mode, is controlled to maintain the temperature of the nitrogen oxide storage unit within a temperature range that allows the storage and reduction of the nitrogen oxides.

8. The engine group as per any one of claims 5 to 7, characterized in that the combustion engine (12) is a direct injection engine.

9 The engine group as per any one of the above claims, characterized in that the electric motor (14) is integrated with the inertia flywheel of the internal combustion engine (12).

10. The engine group as per any one of the above claims characterized in that the combustion engine (12) is an engine with controlled spark (ignition) advance.